

Studies in the Experimental Analysis of Sex.

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With Plates 6-9 and 5 Text-figs.

Part 6.—On the Cause of the Fluctuations in Growth of the Fowl's Comb.

IN Part 5 of these studies ('Quart. Journ. Micr. Sci.,' vol. 56, pt. 3, 1911, p. 591) some observations on the fluctuations in size of hens' combs were recorded, which showed that in adult as well as in young hens the area of the comb may increase or decrease with great rapidity, the greatest increase recorded being 130 per cent. within three weeks. It was proved that these striking fluctuations were independent of any experimental treatment, that they did not correspond with a general increase in weight, and that they appeared to coincide with the egg-laying periods.

The object of this paper is to prove that the correspondence of the comb-increase with egg-laying is invariable, thus confirming by accurate measurements the rough empirical rule by which poultry breeders are accustomed to predict when a hen is about to lay. We shall also show that these rapid fluctuations are characteristic of hen birds, and that they are due to a fatty infiltration of the central core of the comb taking place just before egg-laying commences. Before

proceeding to the proof of these facts, it may be mentioned that the object of Part 5 was to show that the injection of testis-extract had no effect on the comb-increase in the hen, normal control hens giving as wide fluctuations as the experimental birds. The greatest increase in any injected bird was 113 per cent.; the greatest increase in a control bird was 130 per cent., but it appears that this figure does not by any means indicate the limit of increase in a normal adult two-year-old hen, since the same bird has subsequently shown an increase of 201 per cent. within one month.

The fact that the comb-increase corresponds to the egg-laying periods has been proved on two classes of birds: firstly in quite young birds laying for the first time, and secondly, in adult two-year-old birds.

The curves shown in Nos. 1-9 (see Plates) record the increase in comb-area during 119 days of nine young Bankiva hens which were three months old at the beginning of the observations. The period when the egg-laying began is indicated on the curve by the upright lines, the line to the left showing the date of commencement, the line to the right the end of the period. It will be seen in every case that the curve takes a sudden and rapid rise just before, or coincidentally with, the laying of the first egg. Curve No. 3 is seen to be a little irregular, the egg-laying period being broken up into three, a distinct fall in the size of the comb being recorded between the first and second short periods.

Nos. 10 to 13 (see Plates) refer to adult two-year-old birds, the observations extending over a longer period and registering more than one egg-laying period. Nos. 10, 11, and 12 are of adult Bankiva hens, and they show very clearly the close correspondence between comb-increase and egg-laying as indicated by the upright lines. No. 13 refers to a white Leghorn fowl and the same correspondence is clearly shown. Similar records for three other white Leghorns might be given, but the evidence afforded by the thirteen curves depicted is amply sufficient to prove our point.

It will be seen that the time of year has really nothing to

do with the comb-increase, the whole phenomenon being controlled by the periods of egg-laying.

A record was also kept of the weight in grammes of the birds under observation, but it was found that the sudden increase of the comb was not accompanied by an increase in general body-weight. An increase in body-weight generally comes some time before the comb shows its rapid growth, but while the comb-growth is proceeding the body-weight remains stationary or may even sink.

Having established the close correlation between comb-increase and egg-laying, an inquiry was made into the processes occurring in the comb during the remarkably rapid growth periods. If sections are made through the comb of a hen which has recently exhibited a rapid increase, it will be found that the central core of the comb consists of a mass of solid fat, which has completely infiltrated the loose connective tissue usually present in this situation (Text-figs. 1 and 4). Immediately underneath the external epithelium of the comb numerous blood-capillaries are seen cut across, and the walls of the comb are found to consist of fibrous connective tissue. If, now, we take similar sections through the comb of a hen which has recently been decreasing in area (Text-fig. 2), we shall find that the central core is smaller and no longer contains a solid mass of infiltrated fat, but only comparatively few and small fat-globules. The connective-tissue walls of the comb, on the other hand, are not found to have conspicuously diminished in size. The blood-capillaries under the epithelium are fewer in number and more reduced. It is clear, then, that the chief cause of the increase in size of the comb is a fatty infiltration of its central core, and to a much less extent a greater blood supply. Let us now compare the condition in a normal cock bird (Text-figs. 3 and 5). Here it is seen that the central connective-tissue core (*c.*) is small relatively to the fibrous connective-tissue walls (*f.*) of the comb, and that it contains a very few small globules of fat compared to the comb of a female bird. The blood capillaries (*v.*), lying under the epithelium (*ep.*) form a richly vascular

TEXT-FIG. 1.



1

TEXT-FIG. 2.



2

TEXT-FIG. 3.



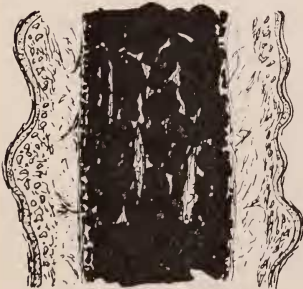
3

Text-fig. 1.—Transverse section through the comb of a Bankiva hen during an egg-laying period.

Text-fig. 2.—Section of a similar hen in a non-laying period, after decrease of comb.

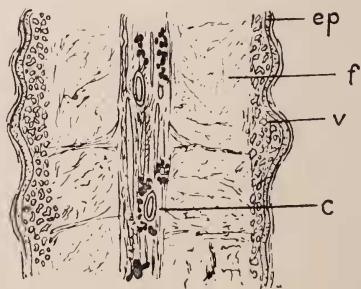
Text-fig. 3.—Section of comb of cock of similar age and breed as foregoing.

TEXT-FIG. 4.



4

TEXT-FIG. 5.



5

Text-fig. 4.—Enlarged portion of section given in Text-fig. 1; female comb.

Text-fig. 5.—Enlarged portion of section given in Text-fig. 3; male comb. *c.* Central core. *ep.* Epithelium. *f.* Fibrous connective tissue. *v.* Vascular area.

Sections stained with osmic acid or Sudan III to show fat.

network. The principal difference between the comb of a cock and of a hen lies in the fact that the former consists principally of tough fibrous connective tissue and is highly vascular, and this is the reason of the erect carriage and bright red colour of the cock's comb. The hen's comb, on the other hand, is not quite so vascular, and has the central core loaded with infiltrated fat, especially at the breeding periods. Hence it has a tendency to droop over when it becomes large and heavy, as the fibrous walls are not powerful enough to support the weight of the fat.

The cock's comb does not exhibit the striking and rapid periodic fluctuations in size characteristic of the hen's comb at the breeding times. At a very early age the cock's comb begins to increase steadily and slowly, so as to outstrip that of the young hen of the same age and breed, but after it has attained its full size it does not undergo any marked alterations in size unless as the result of ill-health. We have shown that the fluctuations in the hen's comb are due to rapid deposition or abstraction of fat from the comb, and since this fat is practically absent from the cock's comb it is easily intelligible why the cock's comb does not undergo any rapid alterations in size.

The conclusions to be drawn from this study of the hen's comb are of considerable importance for our attempt at analysing the changes occurring in the animal body at periods of reproductive activity. At the time when the female bird is forming the large-yolked eggs, and is presumably transferring large quantities of fatty material to the ovary, we observe a change in one of its bodily organs—the comb—due to a deposition of fatty material in it. The blood at this time is probably charged with an excess of fat or yolk-forming material, and this excess which is not taken up by the ovary is deposited in the subcutaneous tissue of the comb, and probably in other situations as well. A correlation is therefore established between the comb and the ovary, which is due, not apparently to any specific internal secretion or hormone elaborated by the ovary, but to the blood becoming

charged with yolk or fat materials which simultaneously affect both ovary and comb.

Now this is exactly the process which we deduced as occurring in the spider-crabs attacked by the parasite *Sacculina*, which assume adult female characters owing to the circulation in their blood of yolk materials similar to that which is stored by the normal female crab in its ovaries at maturity ('*Quart. Journ. Micr. Sci.*,' vol. 55, p. 233). The parasitised crabs, both male and female, do not possess an ovary, but the *Sacculina* forces them to elaborate the yolk material, and the presence of this substance in the blood acts as the stimulus for the development of the adult female secondary sexual characters.

It is of considerable interest to find such closely parallel facts in such widely different animals as Crustacea and birds. In both cases we find that the stimulus for the development of secondary sexual characters does not emanate from the ovary, but that it consists in the presence of fatty materials in the blood elaborated elsewhere and in process of being conveyed to the ovary. That the seat of formation of this fatty material is the liver occurs to us as a natural hypothesis, and it will be fully substantiated in succeeding studies.

SUMMARY.

(1) The rapid and marked increase in area of the hen's comb is proved both in adult and young hens to occur simultaneously with the periods of egg-laying.

(2) This increase of the comb in the hen is due to a fatty infiltration of the central connective-tissue core of the comb; the decrease in the comb is due to the abstraction of the fat. The cock's comb only contains small quantities of fat comparatively in the central core, the substance of the comb consisting principally of fibrous connective tissue. The cock's comb does not exhibit marked fluctuations like the hen.

(3) The increase in the comb is not accompanied by a rise in general body-weight, though such a rise usually occurs some time before the increase and fat deposition occur.

(4) The explanation of the fatty infiltration of the comb is found in the fact that at the egg-laying periods the blood becomes charged with fatty material which is conveyed to the ovary for the formation of yolk, and that the excess of this fatty material is deposited in the comb.

(5) A close parallel is observed in the fat metabolism of the laying hen and of spider-crabs parasitised by *Sacculina*.

EXPLANATION OF PLATES 6-9,

Illustrating Mr. Geoffrey Smith's "Studies in the Experimental Analysis of Sex."

Nos. 1-9 refer to young *Bankiva* hens, three months old at the beginning of the observations.

Nos. 10-12 refer to adult *Bankiva* hens, two and a half years old.

No. 13 refers to a white *Leghorn* hen, two and a half years old.

The curves give the increase in area of the comb measured in square millimetres during a varying period of days. The egg-laying periods are indicated by the vertical lines enclosed above in brackets.